



CHAPTER 1

INTRODUCTION



- To provide an introduction to the basic quantities and idealizations of mechanics.
- To give a statement of Newton's laws of Motion and Gravitation.
- To review the principles for applying the SI system of units.
- To examine the standard procedures for performing numerical calculations.
- To present a general guide for problem solving.



TOPIC OUTCOMES



It is expected that students will be able to:

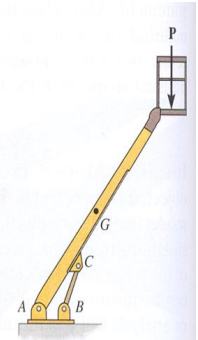
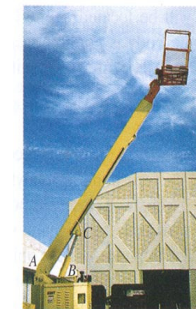
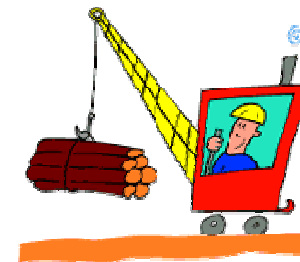
- **Recite** Newton's Laws and express how each of them relates to the different branches of mechanics.
- **Explain** the difference between the weight and mass of an object.
- **Explains** how the gravitational constant (g) relates to Newton's laws and to calculate the value of the gravitational constant.
- **Define** the fundamental quantities of mechanics and to write the correct units for each quantity in either the SI system of units.

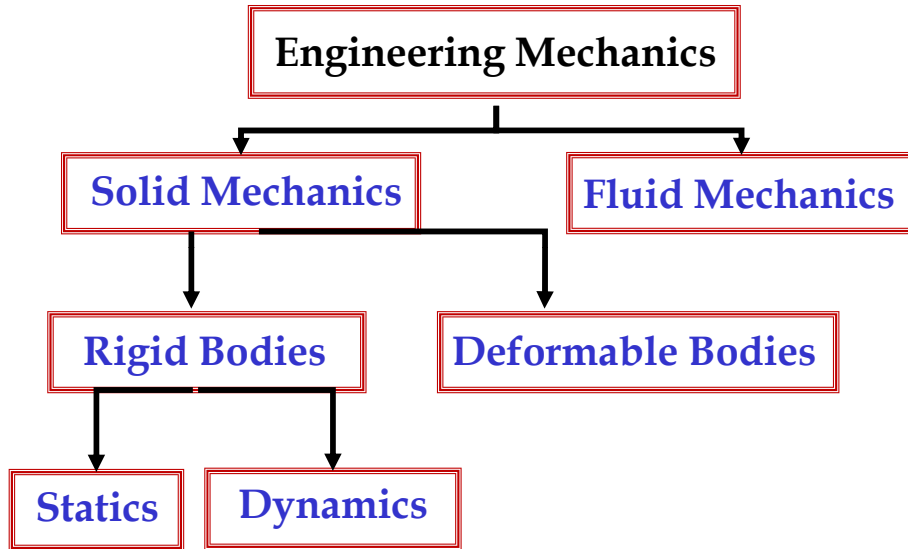


WHAT IS MECHANICS



Mechanics - the physical science which describes or predicts the conditions of rest or motion of bodies under the action of forces.





- In Statics we will assume the bodies to be **perfectly rigid, no deformation**.
- This is **never true** in the real world, everything deforms a little when a load is applied.
- These deformations are small and will not significantly affect the conditions of equilibrium or motion → **negligible**.
- **Rigid body** - a body is considered rigid when the relative movement between its parts are negligible for the purpose at hand

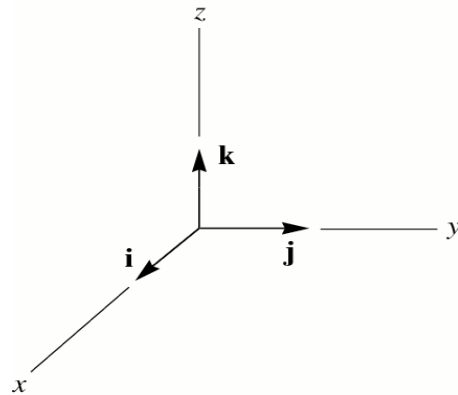


Subdivided into:

- ⊗ **Statics**: a study of resultant and equilibrium of bodies. Utilised to determine the exerted forces (external and internal) investigate a body to be in equilibrium or moving with a **constant** velocities.
- ⊗ **Dynamics**: is concerned with the **accelerated motion** of bodies.



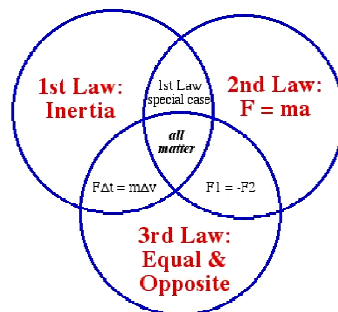
- **SPACE** - the geometric region occupied by bodies whose positions are described by linear and angular measurements relative to a coordinate system.
- **TIME** - the measure of the succession of events
- **MASS** - the measure of the inertia of a body, which is its resistance to a change of motion. Sometimes called "quantity of matter"
- **FORCE** - the action of one body on another
- **PARTICLE** - A body of negligible dimension and it may be analyzed as a point mass



- The parallelogram Law (for the addition of the forces)**
 - Any **two forces** acting on a particle may be **replaced** by a **single force**, called their **resultant**, obtained by drawing the diagonal of the parallelogram which has sides equal to the given forces.
- The principle of Transmissibility**
 - The condition of equilibrium or motion of a rigid body will remain **unchanged** if a force acting at a given point of the rigid body is replaced by a force of the **same magnitude** and **same direction**, but acting at a different point, provided that the two forces have the **same line of action**.



3. Newton's three fundamental laws



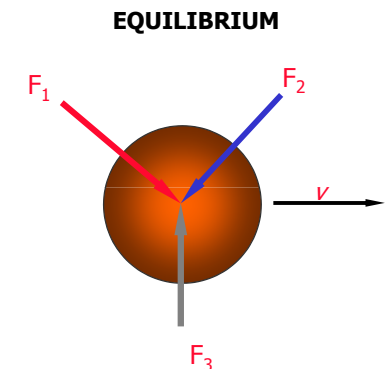
Newton's Laws



3. Newton's three fundamental laws

3.1 First law

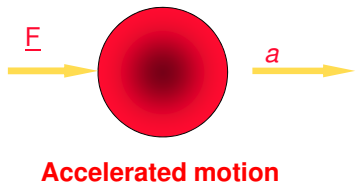
- If the **resultant** force acting on a particle is **zero**, the particle will remain at rest (if originally at rest) or will move with constant speed in a straight line (if originally in motion).





3.2 Second Law

- If the resultant force acting on a particle is **not zero**, the particle will have an acceleration proportional to the magnitude of the resultant and in the direction of this resultant force.



$$F = m a$$

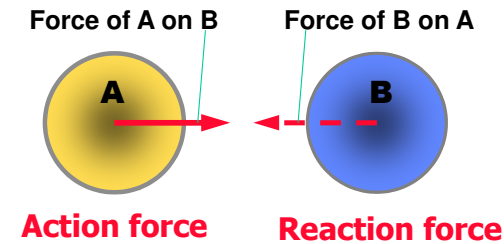
Where:

- F** is resultant force
- m** is mass of the particle
- a** is acceleration of the particle



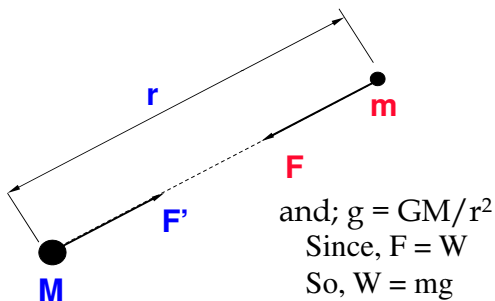
3.3 Third Law

- The forces of action and reaction between bodies in contact have the same magnitude, same line of action and opposite sense.



3.4 Newton's Law of gravitation

- Two particles of mass **M** and **m** mutually attracted with equal and opposite forces **F** and **F'** of magnitude **F** given by the formula;



$$F = G \frac{Mm}{r^2}$$

Where:

- F** = force of gravitation
- G** = universal constant of gravitation
- M, m** = mass of two particles
- r** = distance between two particles



- Base units are units of length, mass and time

| | Length | Mass | Time |
|---------------|-----------|---------------|------------|
| SI Units | Meter (m) | Kilogram (kg) | Second (s) |
| English Units | Foot (ft) | Slug (slug) | Second (s) |

Force: Newton (N)

$$1 \text{ N} = (1 \text{ kg})(1 \text{ m/s}^2) = 1 \text{ kg}\cdot\text{m/s}^2$$

- 1 Newton is the force required to give a mass of 1 kg an acceleration of 1 m/s². Weight is a force.

The weight of 1 kg Mass is:

$$W = mg$$

$$W = (1 \text{ kg})(9.81 \text{ m/s}^2) = 9.81 \text{ N}$$

- Units of Area and Volume:

$$\text{Area} = (\text{Length})^2$$

$$\text{Volume} = (\text{Length})^3$$

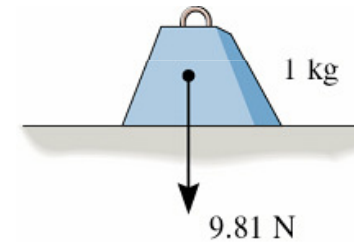


- Modern version of metric system.
- Base units are length, time and mass, meter (m), second (s), and kilogram (kg).
- Acceleration of gravity:

$$g = 9.81 \frac{\text{m}}{\text{s}^2}$$



- Force is derived quantity measured in unit called a **Newton**



$$1 \text{ N} = 1 \frac{\text{kg} \cdot \text{m}}{\text{s}^2}$$

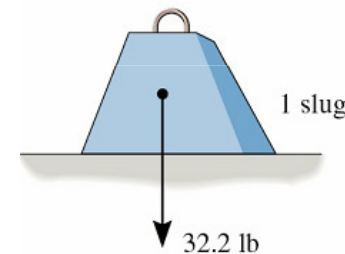


- Base units are length, time and force; feet (ft), second (s), and pound (lb)
- Acceleration of gravity:

$$g = 32.2 \frac{\text{ft}}{\text{s}^2}$$



- Mass is derived quantity measured in a unit called a **slug**:



$$1 \text{ slug} = 1 \frac{\text{lb} \cdot \text{s}^2}{\text{ft}}$$



Force : 1 lb = 4.4482 N

Mass : 1 slug = 14.5938 kg

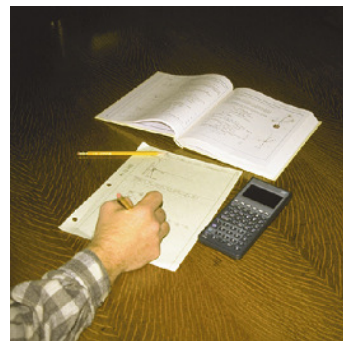
Length : 1 ft = 0.3048 m



- Accuracy specified by number of significant figures.
- Defined as any digit including a zero (provided it is not used to specify the location of a decimal point).
- 5604 and 34.52 both have four significant figures



- When performing calculations retain a greater number of digits than the problem data.
- Engineers usually round off **final answer** to three significant figures. Intermediate calculations are usually done to four significant figures.
- Answer can never have more significant figures than given data!



1. state the given data
2. state the results desired
3. draw necessary diagrams (free-body diagrams)
4. develop equations
5. solve the problem to obtain solution
6. check solution
7. **CHECK UNITS!!**